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MATERIALS INFORMATION

ENGINEERING MATERIALS OFFICE

CONDITION OF EPOXY-COATED REBAR

IN

BRIDGE DECKS

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CONDITION OF EPOXY-COATED REBAR IN BRIDGE DECKS

INTRODUCTION:

The purpose of this study was to determine the in place condition of epoxy coated reinforcing steel just prior to the placing of bridge deck concrete. Cuts and scratches in the epoxy coating expose the rebar to potential corrosion problems and the extent of this damage is of interest. Bridge sites and sample locations were randomly selected to allow the determination of an average condition. The results, determined by calculation of collected visual data, were compared with a study conducted by the U.S. Federal Highway Administration. Ten (10) Central Region bridges of varying size and construction were inspected to give an overall representation.

METHOD:

- Once the rebar was tied in place in the bridge deck, uniform sample areas of 300 x 300 mm were carefully inspected. The location of sample areas were determined by a coordinate system using randomly generated numbers.

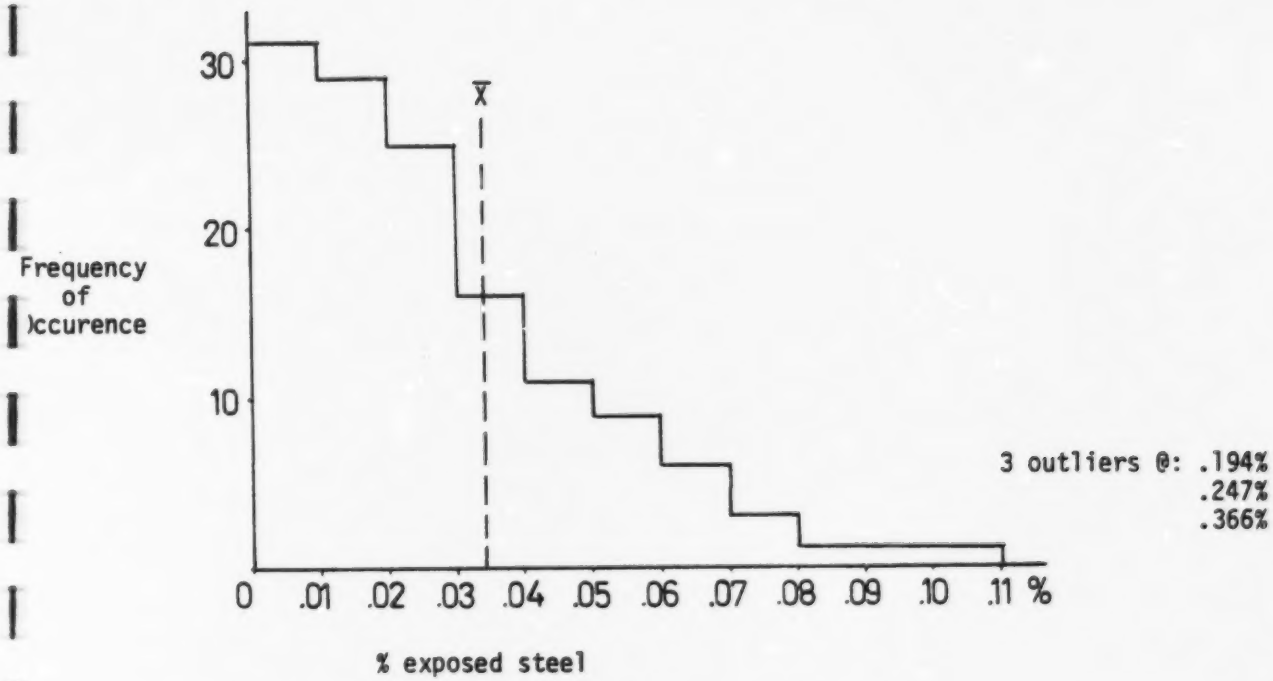
- Each sample was inspected using an inspection mirror and a reference graph for visual comparison of damage.

- The total length and bar size of the rebar was noted as well as the total area of exposed steel in each sample.

- Total surface area of the rebar was calculated using tabled perimeters times the measured length of rebar. The percentage of exposed surface area was determined by dividing the area of exposed steel by the total surface area.

RESULTS:

Fig. 1: Distribution Frequency of % Exposed Steel For All Sampled Areas



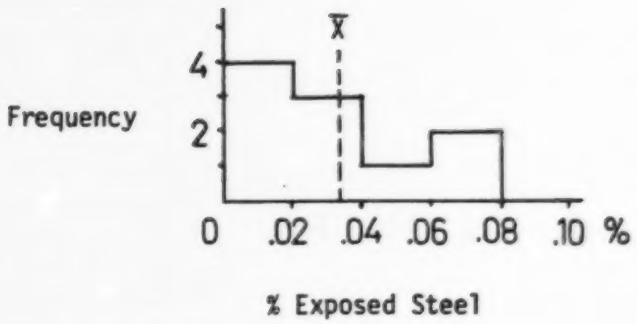
n = 136 test locations (300 x 300 mm)

$\bar{X}$ = .034%

Standard deviation = .057% (based on normal distribution about zero)

Confidence level: There is a 92% probability that damage in any area is less than 0.1%

Fig. 2: Distribution Frequency of % Exposed Steel For Individual Bridges



RESULTS:

Table 1: Average Percentage of Exposed Steel For Individual Bridges

Bridge Type	% Exposed Steel	Contract Number
Thin Slab	.016	82-41
Thin Slab	.010	82-107
Thin Salb	.015	82-106
Thin Slab	.016	82-106
Thin Slab	.031	82-51
Thin Slab	.044	82-89
Void	.025	82-86
Void	.039	82-74
Void	.062	82-23
Rigid Frame	.065	82-85

Mean % = .033%

Standard deviation = .02%

OBSERVATIONS AND INTERPRETATION:

The findings of this study show that the in place condition of epoxy coated steel is well within the following current Ministry guidelines:

"Rejection or repair required to damaged areas:

- Where the damaged area is 25 mm^2 or less and the sum of the damaged areas in any 300 mm length is greater than two percent of the bar area, the bar should be rejected and removed.

- Where the damaged areas are in excess of 25 mm^2 they should be repaired unless the total damaged areas in any 300 mm length of bar is greater than two percent of the bar area in which case it should be rejected and replaced with an acceptable bar."[4]

Field observations confirmed that patching and rejection of damaged bars kept the condition of in place bars well within the above guideline. Greater care in the placing and storage of reinforcing steel could help to further reduce coating damage.

Observations:

- Ends of bars are particularly susceptible to damage, especially on ridges.
- Larger bars tend to receive slightly less damage than smaller bar sizes.
- Loose or insufficient tie wires allow substantial movement of steel when walked upon. Visible damage often results at bar intersections.
- Large damaged areas (>25 mm^2) were rarely found. Largest concentrations of damage occur as series of nicked ridges.

- Black steel (uncoated) causes considerable damage when dragged over epoxy rebar.
- Unsupported stacking of bundled steel on deck deflects mat and damages in place steel.

Current Federal Highway Administration (FHWA) studies offer the following relevant information:

1. Fusion-bonded epoxy coating functions well mainly because of the high electrical resistance of the coating and by greatly reducing the steel surface area available for cathodic oxygen reduction.[1]

2. Data shows that corrosion can be greatly reduced by using even poor quality (.86% damaged) epoxy-coated reinforcing steel in a worst case situation when all of the rebar are electrically coupled. When only one mat was epoxy-coated, it would take an average of 11.5 years to consume the same quantity of iron that was consumed in one year on uncoated steel. If all rebar was epoxy-coated, it would take 41 years to consume the same amount of steel.[1]

3. A visual inspection of new bridge decks in Kentucky showed that of 16 bridges inspected, all had damage of less than 0.4% and 15 of the bridge decks had less than 0.04% damage.

TABLE 2 - EXPECTED LIFE OF EPOXY COATED REBAR[3]

Type of Coating		Amount of Damage	Predicted Service Life (Years)
Top Mat	Bottom Mat	% Exposed Steel	
Uncoated	Uncoated	100%	5
Epoxy	Uncoated	Within Specification Limits	130
Epoxy	Epoxy	Within Specification Limits	449
Epoxy	Uncoated	0.24%	138 *
Epoxy	Uncoated	0.86%	38
Epoxy	Epoxy	0.86%	341

* approximate range of inspected bridge decks

CONCLUSION:

This study found that the average condition of in place epoxy-coated steel in the inspected bridge decks was less than 0.04% damaged surface area. Assuming that an electrical couple exists between the top mat and the uncoated bottom mat, it would appear safe to estimate that the service life of a 0.04% damaged epoxy-coated rebar deck would be more than twenty times longer than an uncoated steel equivalent. (Based on FHWA, Experimental Studies.)[6]

REFERENCES

1. K.C. Clear and Y.P. Virmani, "Corrosion of Nonspecification Epoxy-Coated Rebars in Salty Concrete."; Public Roads, Vol. 47, No. 1, June, 1983.

2. J.R. Clifton, H.F. Beeghly and R.G. Mathey, "Nonmetallic Coatings For Concrete Reinforcing Bars." Report No. FHWA-RD-74-18, Federal Highway Administration, Washington, D.C. February 1974. PB. No. 236424.

3. D.G. Manning, J. Ryell and M. Owens, "Durable Highway Structures-Recent Developments in Ontario."; Report No. EM-65, Ontario Ministry of Transportation and Communications, 1982.

4. E.R. Saint, "Guidelines for Inspection, Patching and Acceptance of Epoxy-Coated Reinforcing Bars at the Job Site."; Engineering Materials Office, Ontario Ministry of Transportation and Communications, 1983.

5. Clear, K.C., "FCP Annual Progress Report-Year Ending September, 30th, 1980 Project 4K." FHWA, 1980.

6. Y.P. Virmani, "FCP Annual Progress Report-Year Ending September, 30th, 1982." Project No. 4K, FHWA, 1982.